

# Newton

## A New Solar System Dynamics Tool

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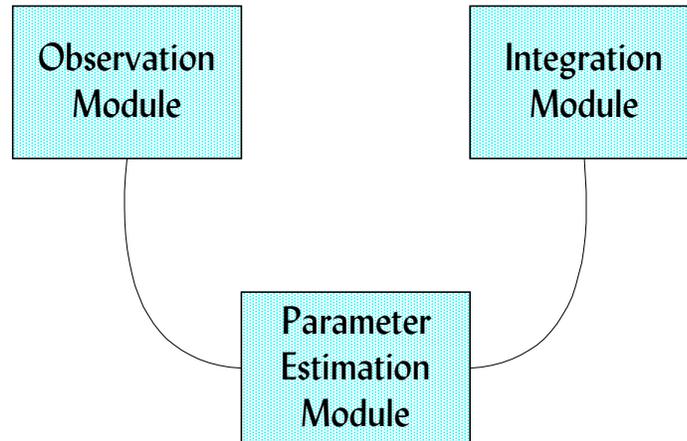
# Motivation

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## ● Need an ODE integrator for Newcomb

- Reliable
- Accurate
- Fast



## ● Need a tool for solar system dynamics research

- Flexible
- Easily extensible
- Chaos diagnostics
  - Frequency analysis (FFT, MEM)
  - Maximum Lyapunov exponent (tangent vector)
  - Trajectory curvature tensor
- Resonance diagnostics
  - Mean motion critical angle
  - Secular resonance critical angles (selectable)

## *Motivation (continued)*

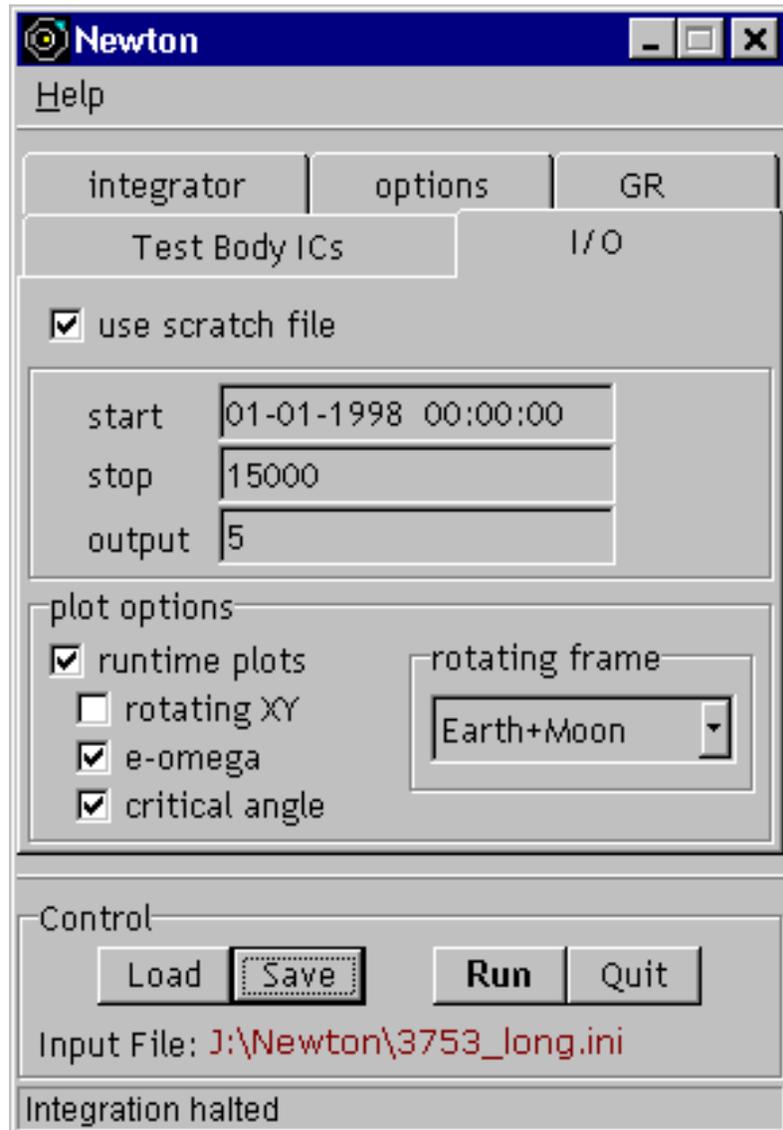
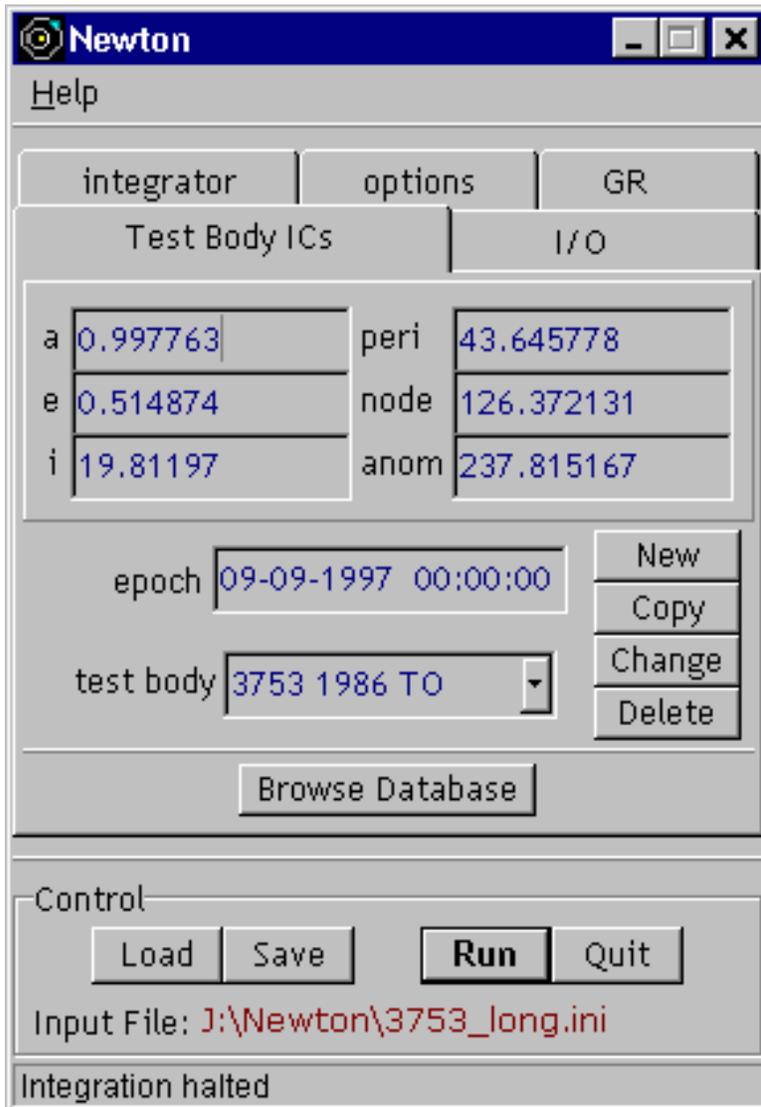
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- **Object-oriented design**
  - C++
- **Newcomb and solar system tool needs overlap significantly**
- **Most efficient answer: a standalone program (for a time)!**
  - Simultaneous Newcomb and solar system tool development for most of the development cycle

# Features – GUI

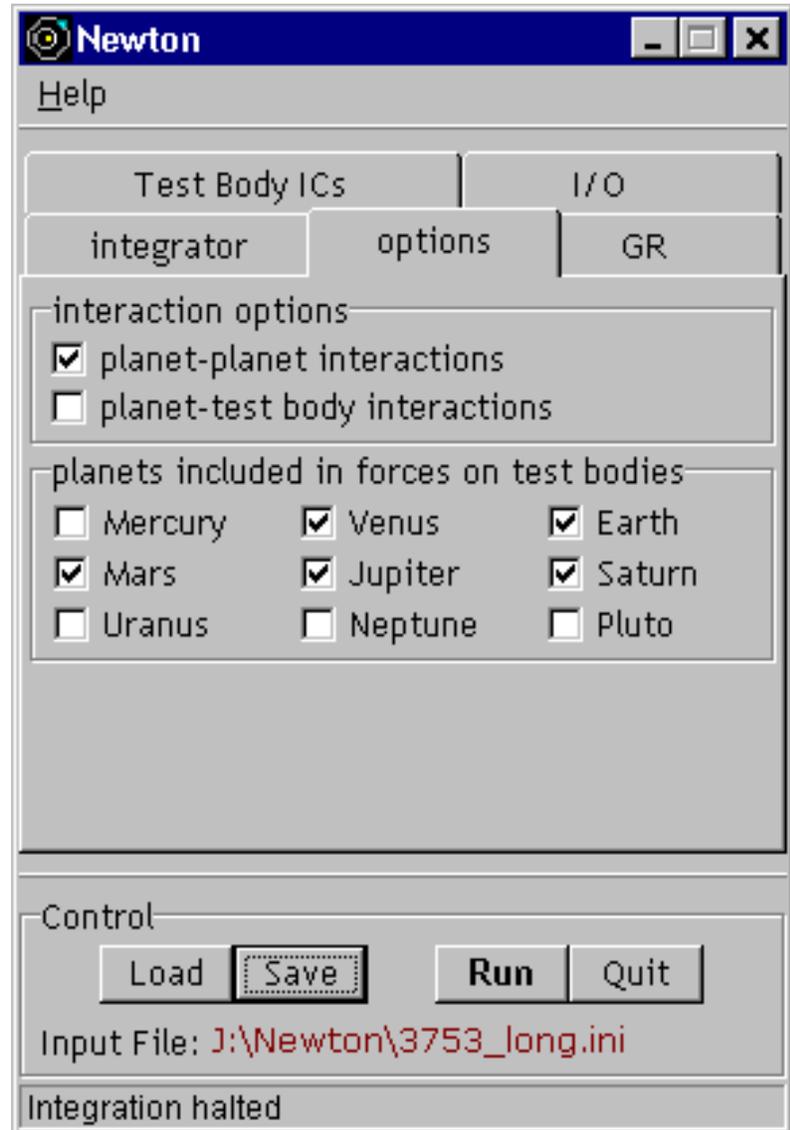
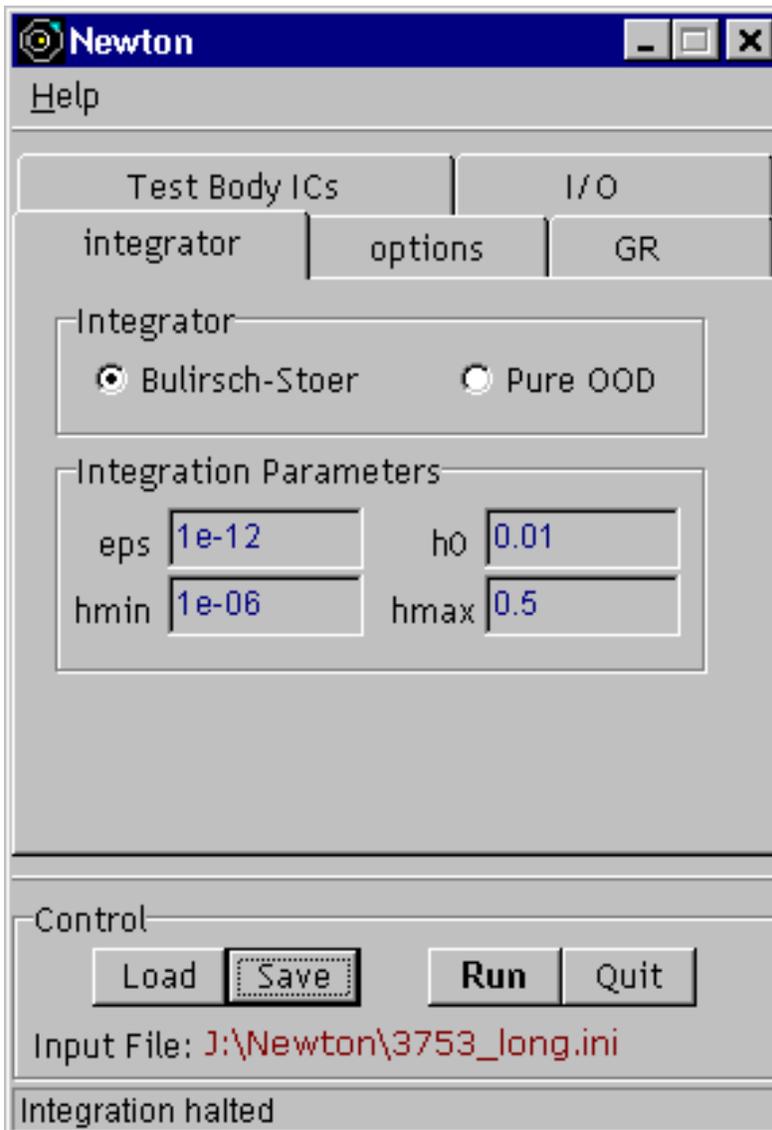
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- Comprehensive, efficient, intuitive GUI



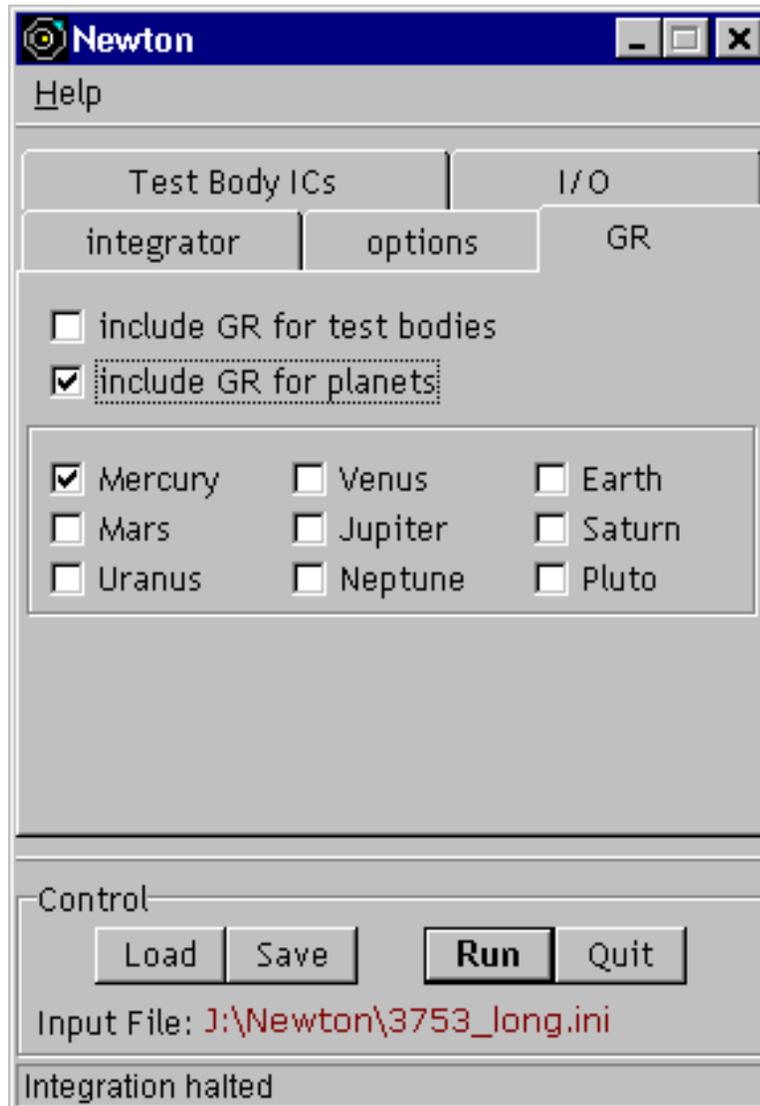
# Features – GUI

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# Features – GUI

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# *Features – Database*

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- Database connectivity for test body initial conditions
  - Selectable databases
  - Search & filtering

# Features – Database

**Orbital Elements Database**

number	name	D(km)	semimajor axis	eccentricity	inclina
2062	Aten		0.96647776	0.18261383	18.93
2063	Bacchus		1.07809268	0.34949521	19.432
3362	Khufu		0.98946916	0.46856905	9.913
3554	Amun		0.97368448	0.28038564	23.36
3753	1986 TO				367 19.81
4034	1986 PA				147 11.16
4544	Xanthus				338 14.14
4581	Asclepius				234 4.906
4769	Castalia				693 8.888
5381	Sekhmet		0.94750548	0.29599763	48.97
5590	1990 VA		0.98522538	0.27920394	14.18
5604	1992 FE		0.9269277	0.40531864	4.793
5786	Talos		1.0814634	0.82686952	23.24

Navigate: First -100 +100 Last rec = 33178

Select Asteroid New Database Cancel

number	name	semimajor	eccentricity	inclination	peri
	1989 UR	1.07979793	0.35585713	10.316883	289.2
	1991 JW	1.03831421	0.1183557	8.721291	301.8
	1991 VG	1.02698083	0.0491725	1.445886	24.49
	1992 BF	0.9082666	0.27027527	7.224578	336.2
5786	Talos	1.0814634	0.82686952	23.249793	8.272

Load Selections Remove Remove All 6 selected

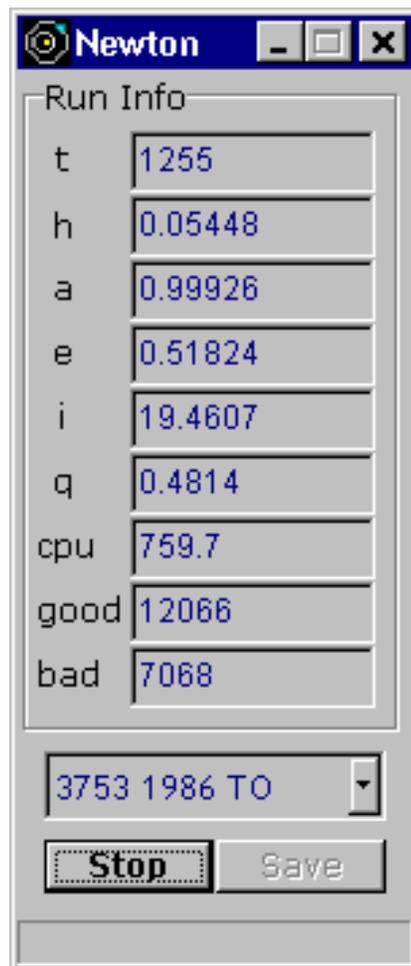
Search: Find Number Find Name

Filter: semimajor 0.9 1.1 Apply Reset 33 records found

# Features – Runtime Information

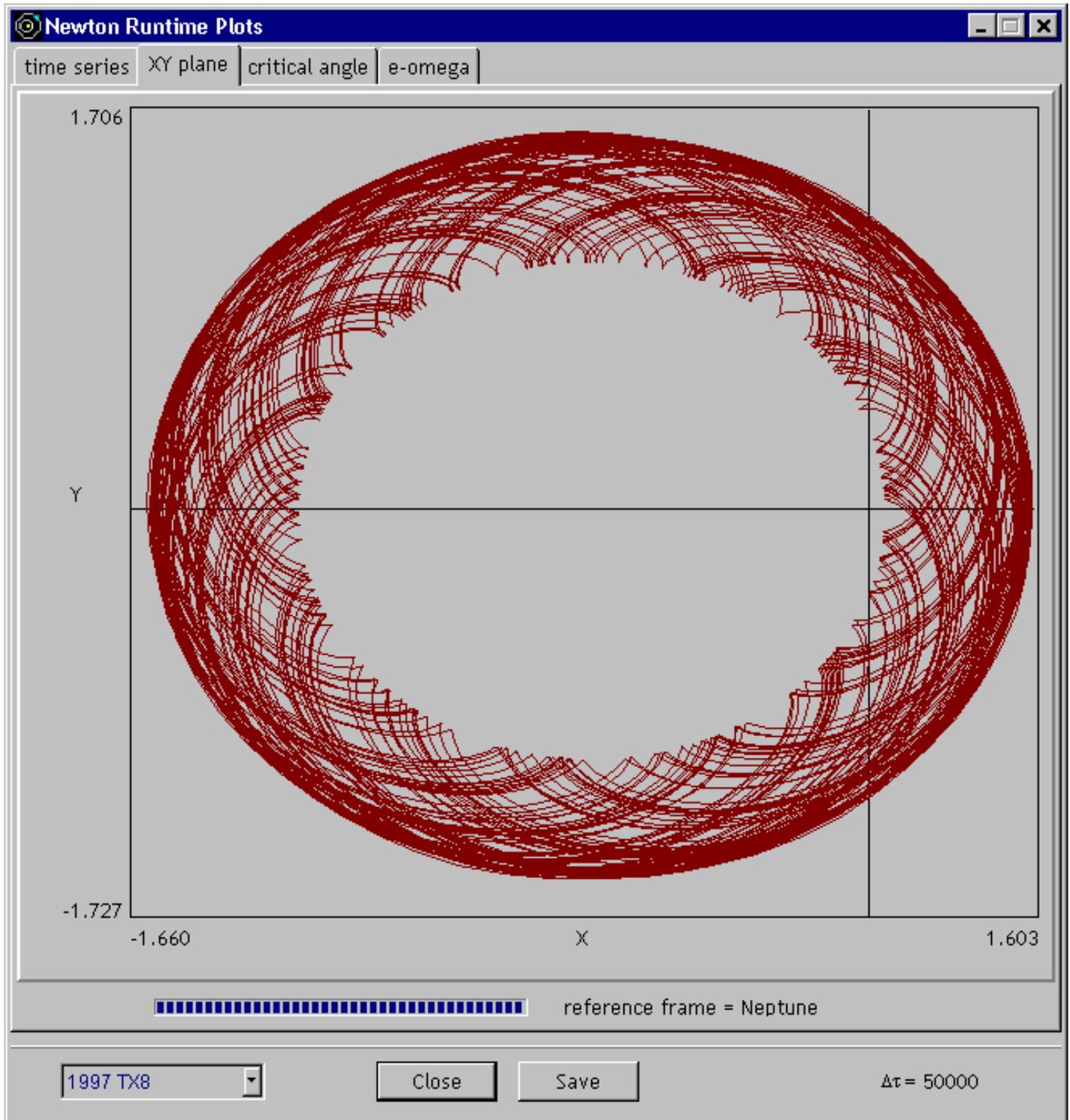
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- Runtime Info

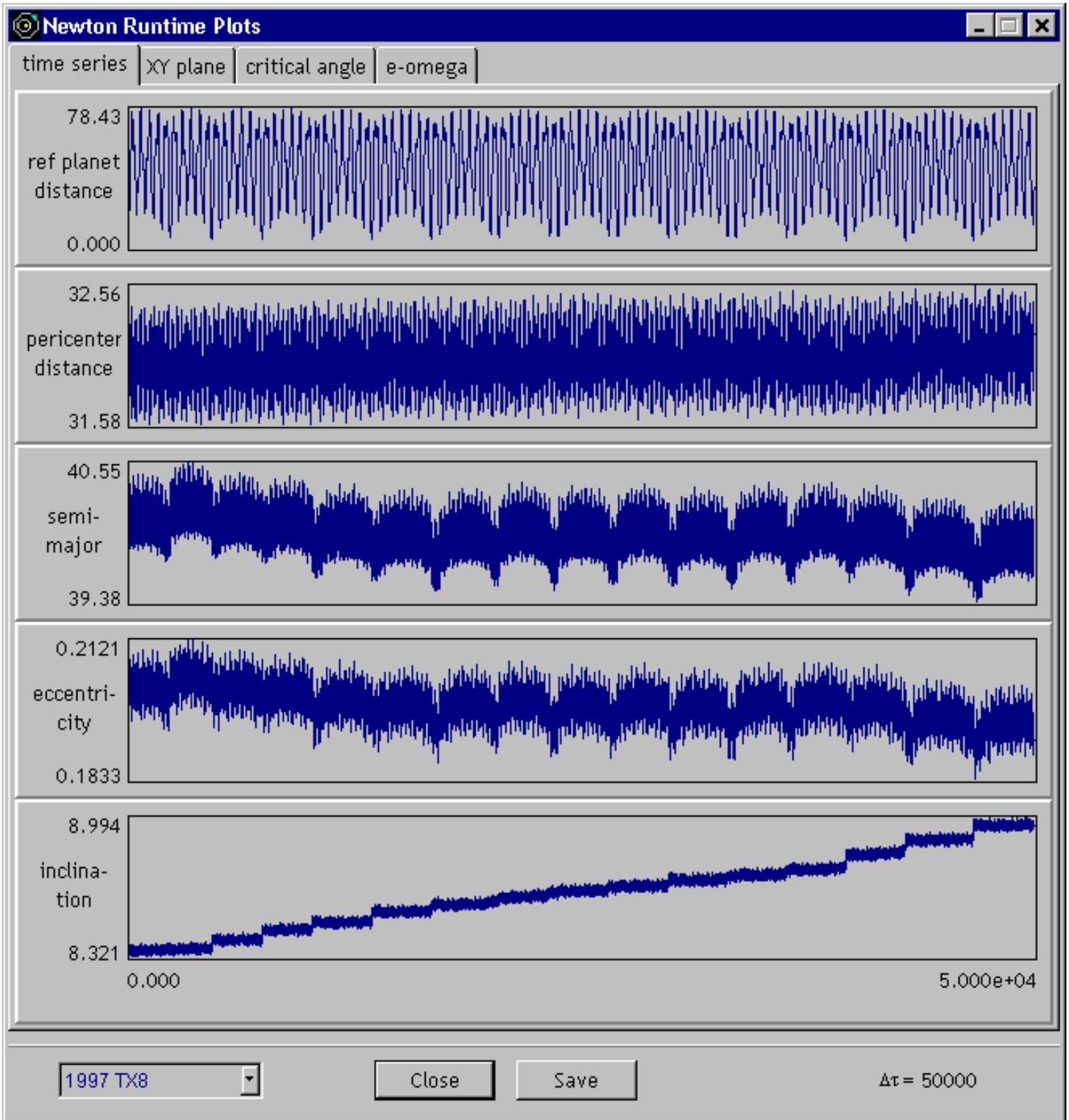


# Features — Runtime Graphics

- Runtime graphics

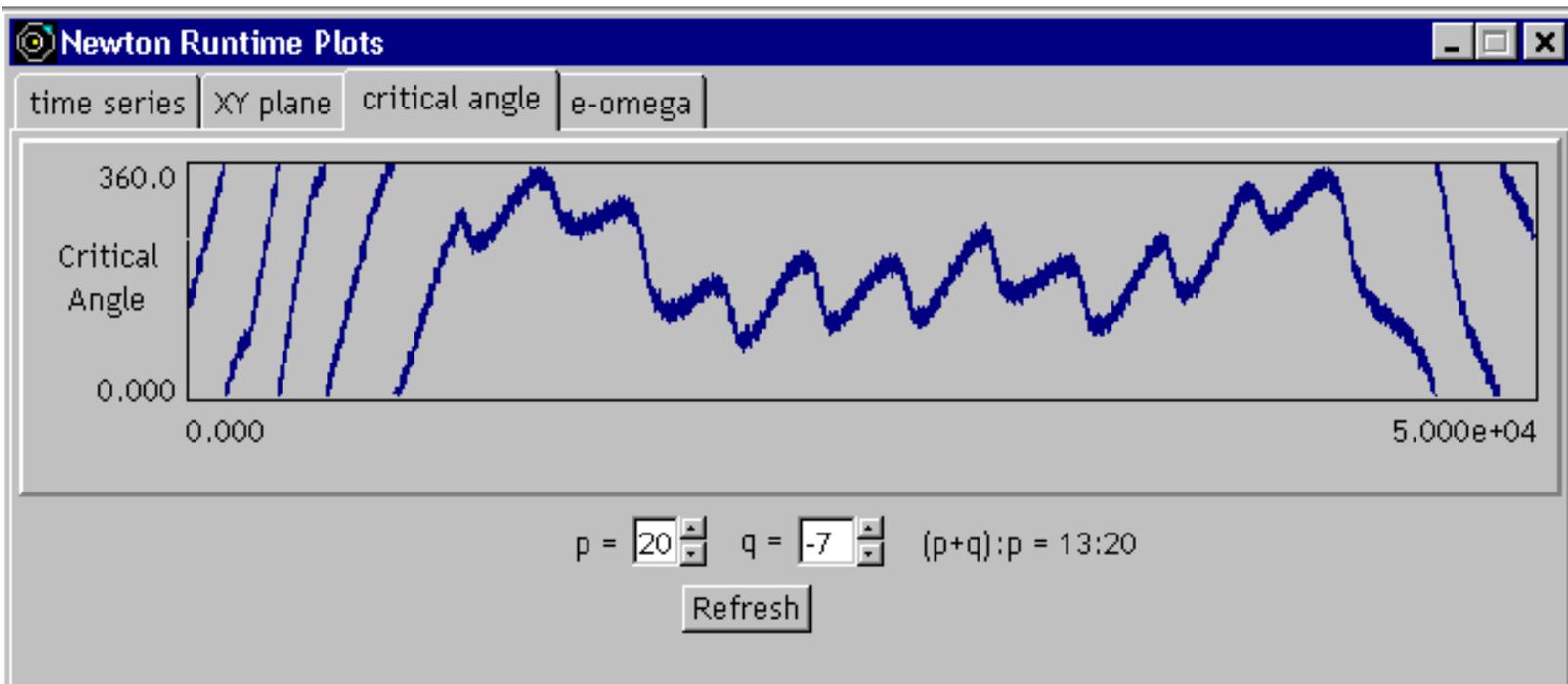


# Features – Runtime Graphics



# Features – Runtime Graphics

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# *Features*

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- Save/read parameters and initial conditions to/from file
- Runtime-selectable rotating/pulsating frame of reference
  - Plots & dialogs automatically adjust
- Runtime data stored on disk or in core
- Interactive mean-motion resonance analysis
- Test bodies may have nonzero mass
  - Interact with each other
  - Interact with planets

## *Features (To Do)*

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- Calculate maximum Lyapunov exponent
  - Incorporate GR in the equations of motion
  - Calculate trajectory curvature tensor components
  - Frequency analysis
    - FFT
    - Maximum entropy method
  - Chebychev polynomials for output data compression
  - Handle unequal test body epochs
  - Read ephemeris data file for planetary positions
  - Classical  $k_G$
  - Generalized secular resonance plots
  - Runga-Kutta 5+7 (for testing & comparison)
  - "Throw planets into Sun"
  - Treat Earth & Moon separately
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# *Current Research Using Newton*

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- **Inner solar system asteroidal dynamics**

- Survey looking for existing dynamically interesting objects
- Resonance effects
  - Overlapping secular resonances
  - Kozai resonances

- **Trans-Neptunian dynamics**

- Dynamical survey
  - Look for peculiar members
  - Discovered a seemingly periodic orbit!
- Mean motion resonances
  - About 1/4 as many in 2:3 resonance as thought by Marsden, Jewitt, and others
  - Some locked into **very** high-order resonances (e.g., 17:29!)
  - Check Malhotra's theory
    - Objects swept up but left behind by resonance sweeping?
- Secular resonances